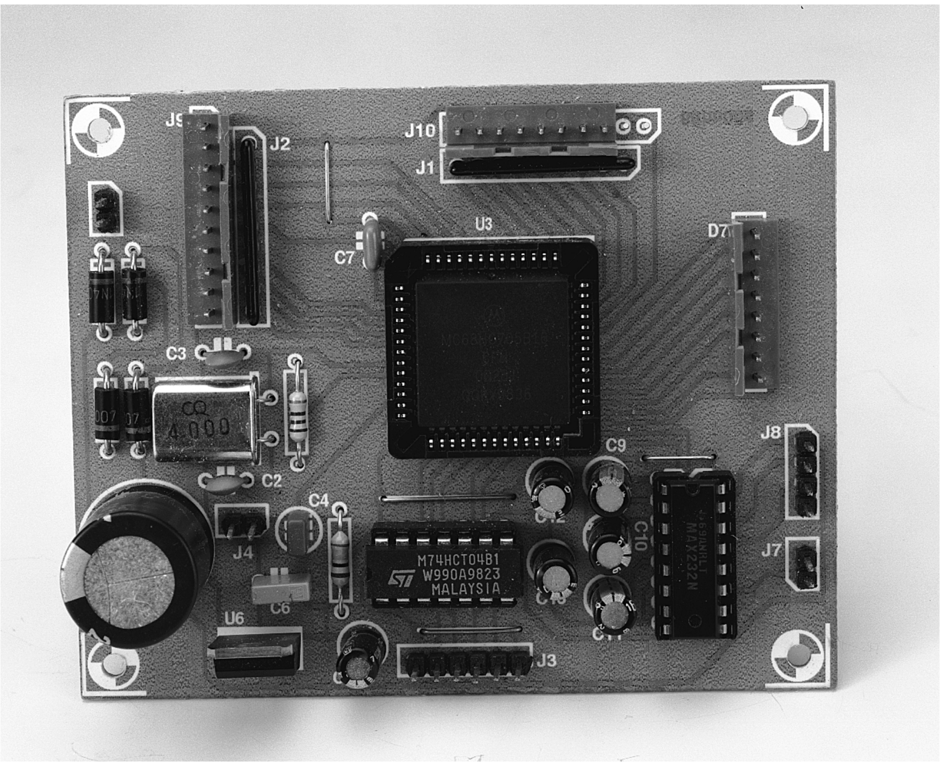
PC-controlled model railway: EEDTS Pro

Part 1: the hardware

The Elektor Electronics Digital Train System published in this magazine in 1989/90 was warmly received by the regrettably declining core of model train enthusiasts. Now, almost ten years later, much of the electronics technology has changed and it is, therefore, felt necessary to update a number of key elements of that system. One of the more important changes is the prominent role given to the personal computer (PC). This development also opens the way to a number of new applications.

Design by S van de Vries



INTRODUCTION

Modern electronics and model train systems get along well together. This is primarily because most electronic components have become so small that they can easily be fitted into a locomotive, turnouts (points; USA: switches), or signals to give these some intelligence. Developments in this field were the subject of an article in the May 1999 issue of this magazine.

The snag with many proprietary model train systems is that they are fairly expensive. The EEDTS of yesteryear showed that it is possible to build a much less expensive alternative. As a bonus, the system is transparent so that it can be incorporated into proprietary systems: locomotives fitted with a Märklin decoder may be readily integrated into the EEDTS. This means that the user has all the freedom he/she wants in building up a model train system.

EEDTS Pro continues along these lines by replacing those components of the earlier system that have become a little long in the tooth, technologically speaking.

In the design, great importance was attached to retaining or obtaining compatibility with existing systems. The result of this policy is that many items of the EEDTS, such as the booster, and the decoders for turnouts (switches) and signals, can be used with EEDTS

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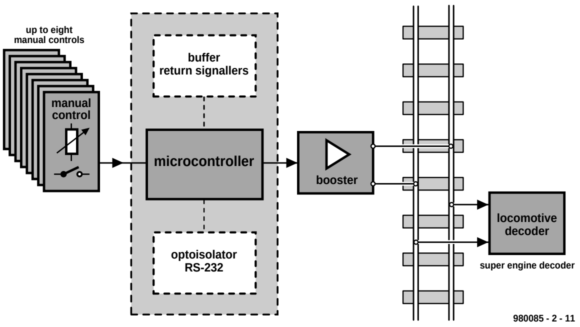
Figure 1. Block diagram of a simple configuration of a model railway.



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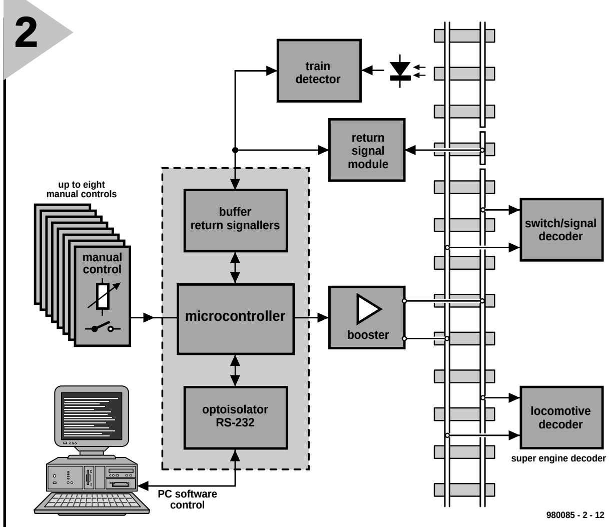

Figure 2. Block diagram of a digital model railway based on the new controller. All requisite functions are readily found in the circuit diagram in Figure 3.

Pro. Proprietary products from, say, Märklin and Lenz may also be used without any problems.

A new aspect of EEDTS Pro is the integration in the control unit of a PC interface to enable monitoring and guiding the trains on the track on the VDU (Visual Display Unit) of the PC. The software necessary for this will be discussed and dissected in next month's instalment.

BLOCK DIAGRAMS

A block diagram of the control system of the model train is shown in **Figure 1**. The solid parallel lines between the booster and the locomotive decoder represent the rails. At the left of these lines is the control section which, in the stand-alone configuration, consists of

Figure 3. Circuit diagram of the controller which is based on a Motorola microprocessor.

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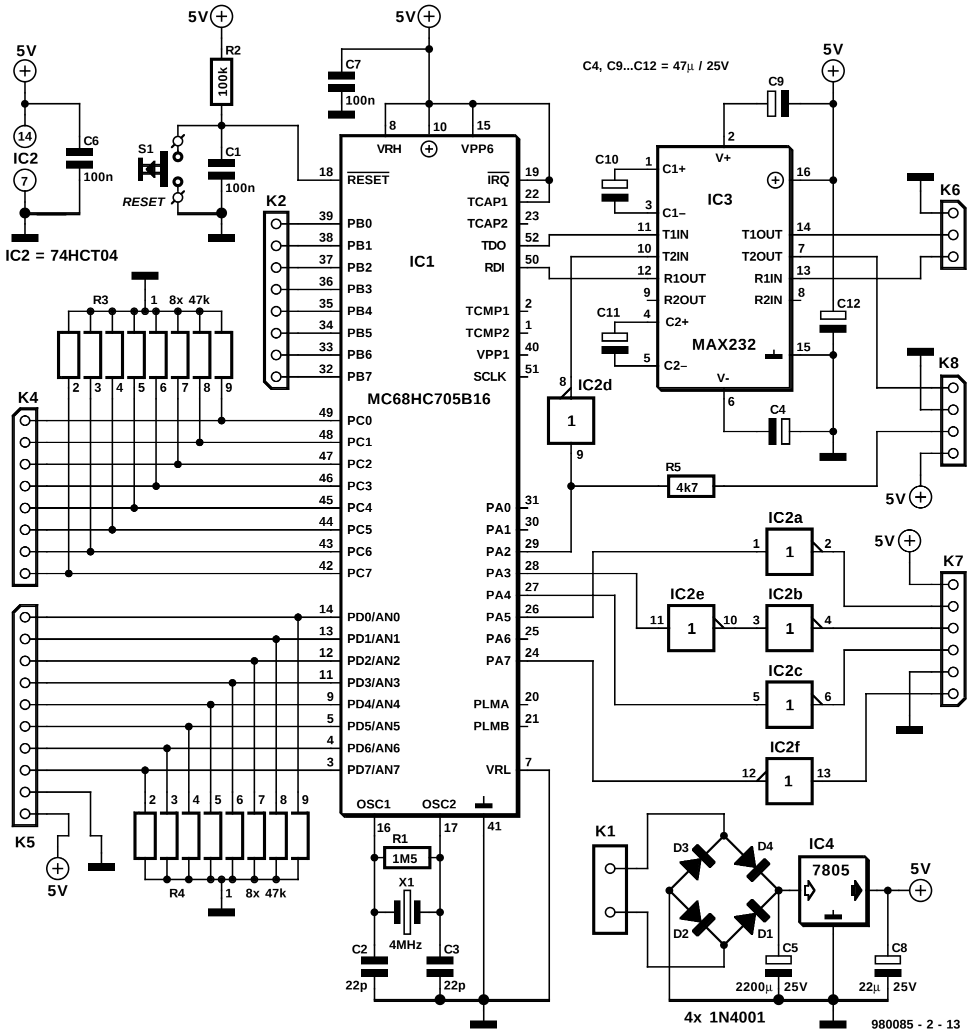

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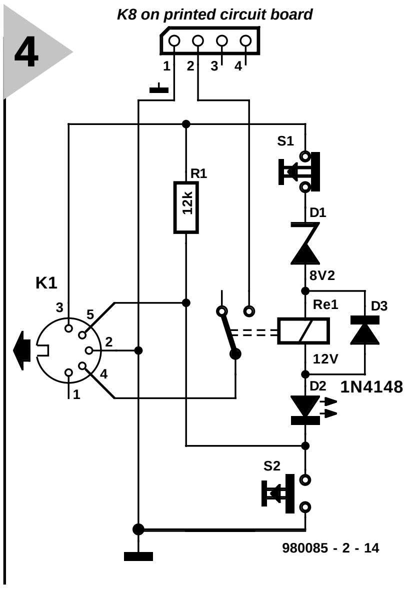

Figure 4. Circuit diagram of the booster interface.

Parts lists BOOSTER INTERFACE:

Resistors:
R_1 = 12 kΩ

Semiconductors:
D_1 = zener, 8.2 V, 400 mW
D_2 = LED
D_3 = 1N4148

Miscellaneous:
S_1 = push-button switch with break contact
S_2 = push button switch with make contact
K_1 = 5≠ pole DIN connector for board mounting
Re_1 = relay, 12 V

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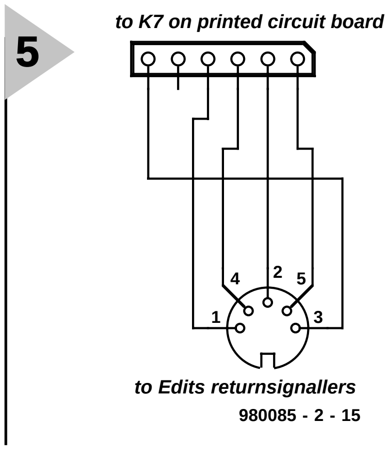


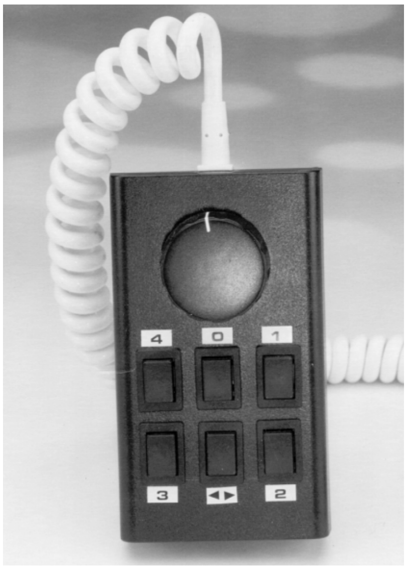
Figure 5. Simple adaptor to enable the monitor units to be connected to the 6-way header on the controller.

up to eight functional controls, a microcontroller, and booster. The digital control signals are conveyed to the track via the booster. With this simple system up to eight independent locomotives can be used on the track.

The engine decoder converts the digital signals on the track into analogue control voltages for the engine. This may take two forms: one that is fitted in the locomotive during manufacture, or one that is built at home and then fitted into the locomotive.

Those readers who use Märklin equipment may note that the EEDTS Pro supports the C80, C81, and C90 decoders (old Motorola format) and the 60901, 60902, C95, and C95/2 decoders (new Motorola format). Compatible decoders and Lenz decoders are also supported.

A new super engine decoder is in the design stages and will be described in a future issue of this magazine.



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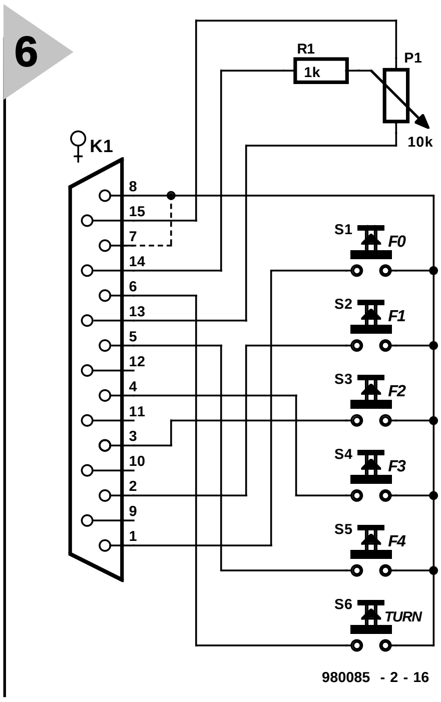

Figure 6. Circuit diagram of the manual control: potentiometer and six switches.

manual control

DB15 connector:

pin 1: to K4 pin 1
pin 2: to K4 pin 2
pin 3: to K4 pin 3
pin 4: to K4 pin 4
pin 5: to K4 pin 5
pin 6: to K4 pin 6
pin 7: to K4 pin 7
pin 8: to K2 pin 1...8 (up to eight manual controls)

pin13: GND (e.g., K5 pin 9)
pin14: to K5 pin 1...8 (up to eight manual controls)
pin15: + 5V (e.g., K5 pin 10)

Parts lists MANUAL CONTROL

Resistors:
R_1 = 1 kΩ
P_1 = 10 kΩ

Miscellaneous:
S_1–S_6 = push button switch with make contact
K_1 = 15-pole female sub-D connector

An engine decoder designed under the old Motorola format enables controlling the speed and direction of a locomotive. There is also a possibility for a third function, such as interior lighting, a steam whistle or decoupling.

EXPANSION

The simple system in Figure 1 may be expanded to that in **Figure 2**. This is based on the units within the dashed lines: buffer monitors, microcontroller, optoisolator, and optional serial link to a computer. A computer may add a new dimension to the model railway.

A computer-controlled track can work only, however, if there is feedback from it to the computer. After all, even a computer is able to control the traffic on the track only if it knows where the trains are. Note that control is purely on the basis of the location of trains. The position of turnouts (switches) or signals is not monitored. They can, however, be controlled by software, as is to be expected from a sophisticated system like EEDTS Pro.

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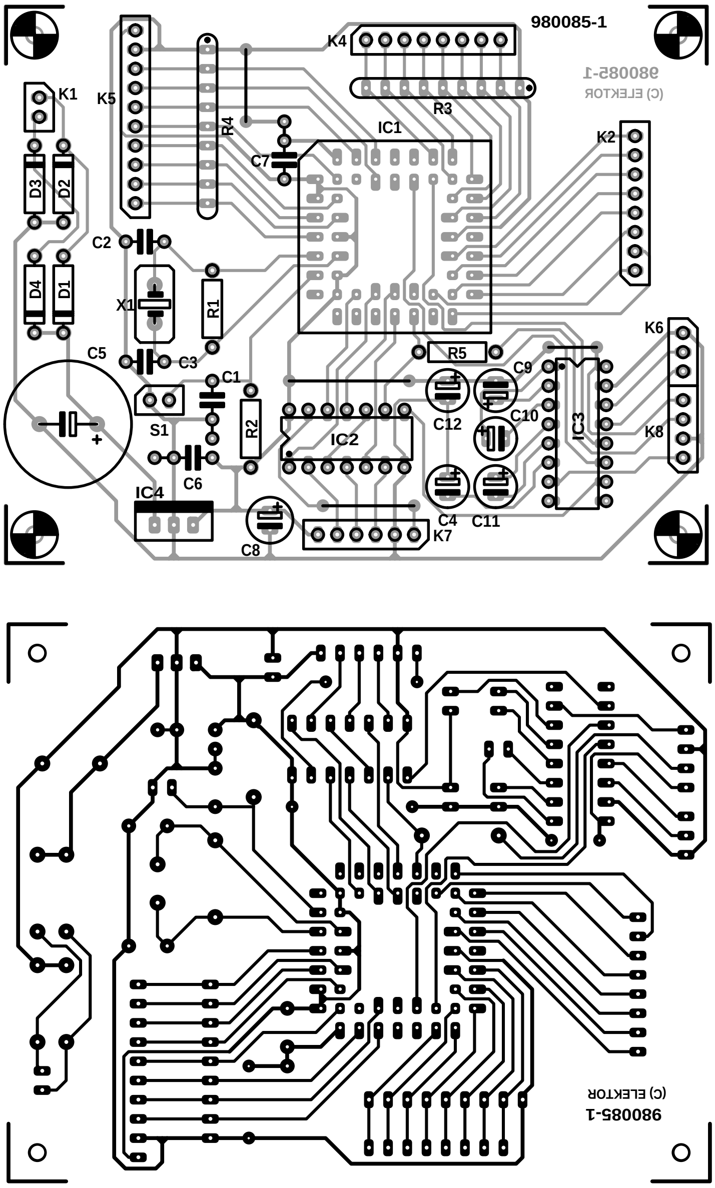

Parts lists CONTROLLER

Resistors:
R_1 = 1.5 MΩ
R_2 = 100 kΩ
R_3, R_4 = SIL array, 8×47 kΩ
R_5 = 4.7 kΩ

Capacitors:
C_1, C_6, C_7 = 0.1 µF
C_2, C_3 = 0.022 µF
C_4, C_9–C_{12} = 47 µF, 25 V, radial
C_5 = 2200 µF, 25 V, radial
C_8 = 22 µF, 25 V, radial

Semiconductors:
D_1–D_4 = 1N4001

Integrated circuits:
IC_1 = MC68HC705B16 (available via our Reader Services, Order No 986518-1
IC_2 = 74HCT04
IC_3 = MAX232
IC_4 = 7805

Miscellaneous:
X_1 = crystal, 4 MHz
S_1 = single-pole switch with make contact
K_1 = 2-fold SIL header
K_2, K_4 = 8-pole SIL header
K_5 = 10-pole SIL header
K_6 = 3-pole SIL header
K_7 = 6-pole SIL header
K_8 = 4-pole SIL header
Diskette, 3.5”, with Windows software, available via our Reader Services, Order No 986027-1a+b

Figure 7. Printed-circuit board for the controller.

DECODERS

A digitally controlled railway needs a number of decoders to control the traffic on the tracks. Apart from the moving trains, there are turnouts (switches), signals, decoupling units, and other components that need to be controlled remotely. Then there are functions within the carriages, such as lighting, which it is nice to control remotely.

Furthermore, it is important for the controller to know where the various trains are located. Monitor units signal the passing of a train and send back this information to the controller.

(MICRO)CONTROLLER

The circuit diagram of the new controller is shown in **Figure 3**. It is compact and wholly digital and is based on a Motorola microcontroller, IC_1. This device provides eight analogue inputs, AN_0–AN_7, three 8-bit I/O ports, a serial connector and an integral oscillator.

The oscillator is configured, together with crystal X_1, resistor R_1, and capacitors C_2, C_3 to generate a clock signal of 4 MHz.

The controller communicates with the computer via an RS232 interface, which is why the level of the TTL signals is raised by IC_3 to enable the signals to be used by the RS232 interface. The computer is linked to header K_6 via one of communication ports COM_1–COM_4.

The single 5 V supply line is converted to the requisite voltage levels by capacitors C_4, C_9, C_{10}, and C_{11}.

There is a second serial output on header K_8, which carries four signals: the booster signal at RS232 and TTL level; the supply voltage; and earth.

The pulse-shaped signals are put on to the track via the booster. The circuit diagram of the requisite booster interface is shown in **Figure 4**. The interface

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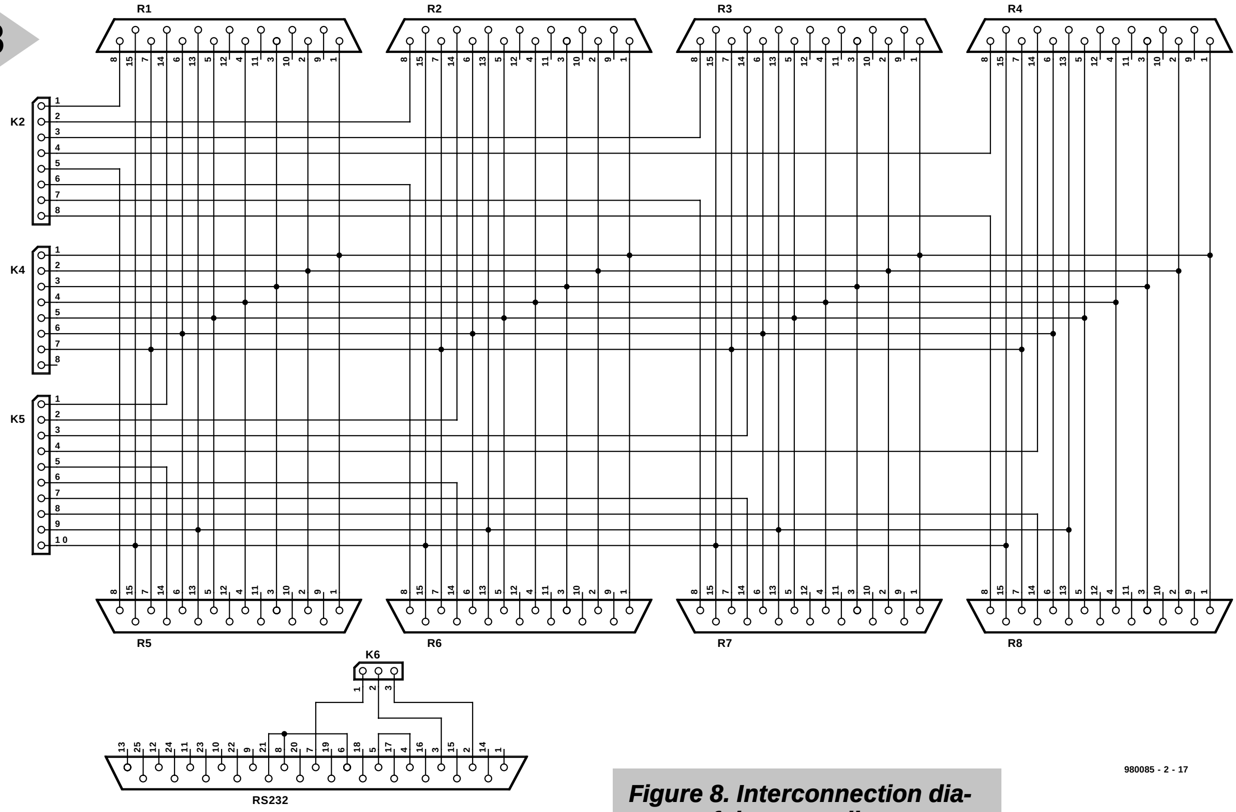

Figure 8. Interconnection diagram of the controller.

adds a start-stop function to the signals. When the booster is actuated by briefly closing switch S_3, the relay is energized, whereupon diode D_1 lights. The relevant data is then passed by the controller to the booster.

When switch S_4 is pressed briefly, the relay is deactuated, whereupon the booster is decoupled from the controller.

When the short-circuit protection of the booster is actuated, the relay is automatically deenergized.

Connections PA_0–PA (port A) are used for communication with the monitor units. The links between the port and the units are 6-core cables, conforming to the Märklin design. The EEDTS monitor units may also be used, but they must be linked via a special adaptor cable, since they use a 5-core cable. How this cable is converted to a 6-way one is shown in **Figure 5**. If a mixture of EEDTS and Märklin monitors is used, insert the Märklin decoders between the EEDTS monitors and header K_7 on the controller.

MANUAL CONTROLS

Ports B, C, and D, on the controller are used for communication with the eight manual controls. The circuit diagram of such a control is shown in **Figure 6**.

Each manual control consists of a potentiometer, with which the speed of the associated locomotive is varied, and a number of switches.

The V_{CC} terminals of all potentiometers are interlinked, as are the GND terminals. The wipers are individually connected to a relevant analogue input on the microcontroller.

Each manual control contains six function keys and a wire bridge. Two of the function keys – reverse and F_0 – are used with both the old and the new Motorola format. F_0 is independent of the direction of travel and is mostly used for controlling the front lights of the locomotive.

The other four keys can be used only with engine decoders that support the new Motorola format. This format is selected by a wire link on the header between pins 7 and 8. When this link is in place, the manual controls may be connected as relevant by a 10-core flatcable. The wire link enables engines driven via the old format or the new format to be used on the same track.

The individual terminals of the function keys are linked to the C-port as relevant, while their common terminals are connected to the B-port. This arrangement enables cyclical scanning of the manual controls.

It is clear that if only the old Motorola format is going to be used, function keys F_1–F_4 may be omitted.

BOOSTER

The booster, that is the amplifier that converts the digital signals to an analogue voltage which is switched between +15 V and –15 V, will not be discussed in this part of the article, but in the next. It is intended that in future the Märklin booster will also be supported. The TTL signals on header K_8 are intended for this booster.

CONSTRUCTION

The controller is best built on the printed-circuit board shown in **Figure 7.** Careful attention to the drawings and parts list should ensure that no problems will be encountered.

Figure 8 shows how the manual controls are interconnected and linked to the various headers.

RAILWAY MODELLING IN THE UK

There are a number of model railway magazines, but these may not always be available from newsagents without being ordered.

Railway Modeller • Peco Publications & Publicity Ltd • Underleys • Beer • Seaton • Devon EX12 3NA.

Model Railway Journal • Wild Swan Publications Ltd • 1–3 Hagbourne Road • Didcot • Oxon OX11 8DP.

Model Railway Enthusiast • Link House Magazines Ltd • Link House • Dingwall Ave • Croydon • Surrey CR9 2TA.

Further information may be gleaned from:
http://www.geocities.com/CapeCanaveral/7045/railmodel.html

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